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A BASIS FOR A COMMAND, CONTROL AND
COMMUNICATIONS (C3)
SYSTEM ARCHITECTURE FOR THE
ARGENTINE ARMY

by

Juan Carlos Maidana

March 1990

Thesis Advisor: D.C. Boger

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A Basis for a Command, Control, and Communications (C3)
System Architecture for the Argentine Army

by

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ABSTRACT

This thesis represents an initial effort to define the characteristics of a command, control, and communications (C^3) architecture. It provides a basic understanding of the command and control process, command, control and communications architecture, and command, control and communications system analyzed from the point of view of an information system. The ultimate goal of this thesis is to introduce the basic concepts of C^2 process, C^3 architecture and C^3 system to the Argentine Army.

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I. INTRODUCTION

A. BACKGROUND

Military commanders throughout history have faced the problem of controlling their forces for decisive application of military power. [Ref. 1: p. 9] Their objective is to control a particular area of land through imposing their will against the enemy. In order to achieve this objective, the commander needs information, both before the actions and while the actions are taking place. Command and control (C^2) provide the appropriate tools to attain this objective. Success in battle cannot be attained without C^2.

The existence of C^2 as a fundamental piece of the contributing elements of battle is not a revelation. Military history is replete with examples that demonstrate this point. In the Second Macedonian War, the Roman Army under Titus Flamunius, brought King Philiph V from Macedonia to bay at the battle of Cynosephalae in 197 B.C. The opposing armies were roughly equal in numbers. The Romans fought in maniples organized in groups of about a hundred men, each with his own commander and capable of flexible movement and control. The Macedonians employed the phalanx --an unwieldy solid line of troops armed with 20-foot pikes and almost impossible to control or maneuver because of its length and rigid formation. Philip attacked the Roman maniples with 32 phalanxes, planning to overwhelm them with the sheer mass of his force. The front phalanx broke around the maniples as they were pressed forward by the ranks following them. They lost all cohesion and order, and the small disciplined maniples with their short thrusting swords decimated them. The Romans lost about 700 men. The Macedonians suffered 80,000 killed and 5,000 captured. There were, of course, many factors contributing to Flaminius' overwhelming victory, but one of the most important was the execution of the commander's control over small and maneuverable forces. [Ref. 2: p. 16]

Another more recent example is the German victory over a vastly superior Russian force during the Battle of Tannenburg in 1914. The Germans added radio and cable communications as well as communications security to their C^2 systems in this case. The German High Command adapted the communications procedures to be employed in battle to its standard process of command and control. Tannenburg is known as the

Cannae of modern times because of the superior use of military tactics and doctrine in this battle. This was largely possible through the effective use of communications by German forces which permitted flexible and responsive command and control (C^2). The Russians, on the other hand, were often immobilized by lack of communication and could not swing their forces to exploit tactical advantages on the battlefield.[Ref. 3: p. 34]

These are notorious examples where C^2 was decisive in managing the battle, but in fact in every battle, command and control play a fundamental role. Recently the technological revolution has brought many changes in human activities including the art of waging war. Electronic technology in its many forms of transmission, processing, collation, distribution and analysis was the catalyst which precipitated what is known as the discipline of C^2. But C^2 is much more than just the materials and elements necessary to handle information (hardware and sotfware). It includes both the people who make the decisions and those who operate and maintain the systems. In a very real sense, C^2 encompasses the management of information that can make a difference to a decision maker.

B. PURPOSE

The process involved in combat operations which optimize the performance of friendly forces and the information system architecture which supports those operations will be described in some detail in this thesis. The ultimate purpose of this thesis is to help the development efforts of the Argentine Army in designing a C^3 architecture through the presentation of the basic concepts of command and control processes and command, control, and communications systems. This is only a suggested guide to the main aspects related to C^2 and C^3 to be presented to an army whose current doctrine does not contain those concepts. This is an attempt to put together related facts found in the military literature with the objective of helping the people who are now working on the C^2 area in the Argentine Army.

C. ORGANIZATION AND SCOPE

This thesis can be divided into three parts. The first part includes Chapters II, III and IV. This part introduces the definitions and processes of C^2. Chapter II gives a series of the current definitions of C^2, C^3, C^3 I and other terms that military use has made

popular. The different models or perceptions that bound C^2 are also presented in this chapter. Chapter III introduces the basic concepts of C^2, its purposes and the means used in its implementation. The models, from the basic approach to more complex organizations, are introduced in a systematic way. Chapter IV introduces the combat models developed for the execution of the command and control of engaged military forces. Human and psychological aspects are taken into account in this approach, particularly in the decision making activities.

The second part includes Chapters V and VI, and it is designed to broadly describe the combat information system architecture and give an idea of the state of the Argentine Army C^3 project. Chapter V reviews the architecture at different levels of the whole information system that supports the army's activities, from the strategic or theater level to the tactical level. Some aspects of the Air Land Battle related to C^3 are also introduced in this chapter. Chapter VI describes the current state of the Argentine Army C^3 project, the steps to take to reach the objective, and the probable evolution of the C^3 project. Finally, Chapter VII gives the conclusion of this thesis.

II. THE GENERAL CONCEPT OF COMMAND AND CONTROL (C^2)

A. INTRODUCTION

The concept of command and control (C^2) has long been used in various aspects related to military forces. C^2 is one of the most used and abused term in the military literature. It has been used to mean everything from military computers to the art of conducting military operations. In the last few years, C^2 has been symbolized by many terms, such as: C^3, C^3 I, C^4 , and C^4 I. [Ref. 1: p. 13]

B. DEFINITIONS

1. Department of Defense (DOD).

The different terms mentioned above are not easy to define. A good starting point is the official US Department of Defense (DOD) definition for C^2 :

> The exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures which are employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission.

This definition can be seen as containing three different definitions. "The exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission" is the definition of command. "An arrangement of personnel, equipment, communications, facilities, and procedures which are employed by a commander" is the definition of C^3 system, and the expression "employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission" is the definition of command and control. Each of the three parts in which the original DOD definition has been divided is a specific entity and will be explained in detail in this chapter.

2. Robert E. Conley.

To clarify the concept of command and control, the definition given by Robert E. Conley helps [Ref. 4: p. 15]:

> Command and control (C^2) is a process of resource allocation (management) by a knowledgeable, recognized point of authority to accomplish a given objective(s).

This definition is useful because it is brief and broad enough to be confidently applied. This definition also is coincident with the natural perception of the idea of command and control in the military world: a process by which a military objective is accomplished with the resources available by an officer in a military command position. The general nature of the definition, however, applies to other management areas and is not limited to the military. The contribution of this definition to the understanding of C^2 is that it introduces the term "process," which is the key word in the C^2 concept.

C. MODELS AND PERCEPTIONS

Although, in general there is agreement that new technologies have an impact on C^2, there are many different opinions about what is really new and revolutionary in battle support systems. Such different opinions give rise to various models of C^2 and C^3. Based on common aspects of these views, K. L. Moll defines three models which he calls "perceptions." [Ref. 5: p. 23]

1. The electronic perception.

Most people perceive C^3 as a collection of electronic hardware and computer software. Although this is a simple and primitive view, it is a natural organizational procedure. The electronic perception makes little distinction between C^2 and C^3.

2. The mirror perception.

Many observers of C^2 and C^3 perceive them to be a mirror of their own interests and activities. From this point of view, the classical definition of C^2 is a mirror perception of the command function. Commanders and military historians often associate C^2 with the organization of channels of command over some particular forces. In this case, they rarely distinguish between C^2 and C^3 . Communicators often see C^2 as a reflection of communications. Communicators provided the main resource for planning and

maintaining the early C^2 systems. The concept that "combat operations never could be accomplished without command and control coordinated through specialized communications"[Ref. 6: p. 11] may account for the origins of C^3 systems. Computer technicians sometimes see C^2 as mirroring automation, making the computer like the heart, a really key component of the system. The term C^4 appears to ensure that computers, like communications , are given separate recognition.

3. Process perception.

Earlier, C^2 was defined as a process, or more specifically "a process of allocation of resources, by a knowledgeable recognized point of authority to accomplish a given objective," [Ref. 4: p. 15]. However, frequently C^2 is visualized as a "management information system" with feedback loops and other elements of cybernetics, control, and decision theory.

The process perception provides the basis for the definition of C^2 given by the Strategic Air Command (SAC):

> An information handling process which provides an inward flow of data to the decision making level and the subsequent outward flow of directives to subordinate levels of command. It is not a decision making process in itself, but rather a combination of the means through which the factors that shape decisions are funneled to appropriate command levels and the vehicle through which a commander disseminates directives to complement these decisions. It is cyclical in its nature...[Ref. 7: p. 46]

Comparing the three perception models given by Moll to the process perception, it can be said that the latter is closer to what command and control really is. Fundamentally, C^2 is a process. Electronic hardware and computers give physical support to the closed loop nature of the process.

D. THE C^3 SYSTEM

Recalling the point that C^2 is a process, it follows that a C^3 system is one which supports that process. In general, a C^3 system can be considered as a collection of people, procedures, and equipment which allows a commander to sense, compare, decide, and act. [Ref. 1: p. 18] The meaning of these terms will be explained in detail in Chapter III. However, those terms are implicit in the definition issued by Dr. Gerald P. Dinneen

(Former Assistant Secretary of Defense (Communication, Command, Control, and Intelligence)):

> The C^3 systems of the DOD are the means by which our military commanders, under the direction of the president as the commander-in-chief, employ the military strength of our nation. Reliable communications, information processing, surveillance and warning, electronic warfare and counter-C^3 are essential for effective C^3. [Ref. 8: p. 10]

Another definition for a C^3 system focuses on the characteristics of systematization. Systemizing shows the characteristics of assemblage of objects united by some form of regular interaction or interdependence:

> The command, control, and communications system is a collection of elements which display the properties of the command and control process. [Ref. 5: p. 25]

From the point of view of a system, C^3 can be seen as a set of different parts, whose relationships and interactions work synergistically to accomplish an objective. The system is embedded in the environment in which command and control must operate.

In other words, it is the purpose of a C^3 system to observe and provide warning and assessment of the intentions of adversaries, to collect and process information on the status of friendly and hostile forces, to support operational planning and decision making, and to communicate commands to forces. Although the concept of systematization has been introduced through the utilization of the command and control concept, it is important to emphasize that in many cases the term C^2 system is utilized in place of C^3 system. However, the rest of this thesis will employ the term C^2 for the process and C^3 for the system.

A more simplified approach to explaining a C^3 system is to draw an analogy between it and the human body system:

> Stimuli are received through the body's sensors (eyes, ears, nose, fingers, etc.) and the nervous system transmits this data to the brain, which interprets this data into information and makes decisions. Then the commands to take actions are relayed via the nervous system, from the brain to the limbs. Thus sensors such as radars

send information over communication systems to the command center (brain) where commanders make decisions and disseminate the decision back (over the nervous system) to the combat forces (the hands, the fists, the punch). The system of C^3 must be kept in balance to have an effective fighting force, just as the living system must stay in balance to function properly. [Ref. 9: p. 33]

E. OTHER TERMS

An aggregation of related elements gives rise to a C^2 shorthand that is sometimes overused in the military literature. The reasoning that follows shows the evolution of these terms: the need for communication systems for connecting the commander with his forces and to his sources of data results in creating C^3 systems. The need of the commander and his staff for staying informed about the enemy results in the C^3 I system (Command, Control, Communications, and Intelligence system). The need for information processing to store, process, and manipulate data results in the C^4I system (Command, Control, Communications, Computers, and Intelligence system). The need for command facilities or fusion centers where essential information can be assembled, integrated, and displayed to provide the commander the ready means for his planning, executing, coordinating and controlling results in the C^6I system (Command, Control, Communications, Computers, Command Center, and Intelligence system). The need for interoperability at levels of command results in the C^6I^2 system (Command, Control, Communications, Computers, Command Center, Intelligence and Interoperabilty system). And finally, the need for position and location systems and identification systems in order to keep the commander informed and provided with a clear and accurate perception of his environment results in the C^6I^2PLRS (Command, Control, Communications, Computers, Command Center, Intelligence, Interoperability, and Position Location Reporting System). and so on to C^nI^m. [Ref. 10: p. 6]

The seemingly limitless combinations of "Cs" and "Is" do not provide an exhaustive list of all elements that must be considered when examining C^2 functions. There are other terms like C^2 CM (C^2 Countermeasures) approved by the DOD, which means the use of both lethal and non-lethal capabilities for attacking the enemy's C^3 structure, while protecting one's own. Others prefer the term C^2 W (C^2 Warfare) instead of C^2 CM in order to avoid a "reactive" connotation to the term countermeasure, preferring the other more "proactive" term of warfare.

F. SUMMARY

This chapter is designed to introduce several definitions of command and control, and command, control and communication systems. Some models or perceptions have been presented in order to understand the particular points of view of recognized professionals in the C^3 community.Finally, it was shown how the aggregation of terms have given rise to a lot of acronyms which are often used in the C^3 literature.

As a conclusion, it can be said that command and control is fundamentally a process. A dynamic feedback characterizes this process. The physical elements supporting the process in a coordinated manner described the comnand, control and communication system. However, in many cases, the terms C^2 system and C^3 system are used interchangeably.

III. THE C^2 PROCESS

A. INTRODUCTION

The last chapter introduced the basic definitions and concepts of C^2. As was said before, C^2 --in simplest terms-- is a process: the process by which a commander exercises authority and direction over assigned forces in the accomplishment of his mission. The functions involved in this process and the means that support the process will be explained in this chapter.

B. THE C^2 PROCESS AND ITS PURPOSE

The "paramount decision" is the decision to engage the enemy (or if engaged, to disengage) which relates to the deployment and motion of resources and assets assigned to the human military commander to carry out a mission specified by higher authority. Thus, C^2 can be described as a process which allocates resources.

A model of the C^2 process will be presented, discussing in detail its principal functions. Conceptual models will be constructed from previously developed concepts. The models presented in this paper are attributed to Dr Joel S. Lawson, Sr, from the Naval Electronic Systems Command, and are taken from his report entitled: "The State Variables of a Command and Control System." [Ref. 11: p. 61]

These models emphasize the process perception of command and control. A process, in broad terms, can be defined as a method of doing something with all the steps involved [Ref. 12: p. 131]. Considering C^2 as a process leads naturally to the question of what is the output of that process? Quite clearly, in the eyes of the political leadership of a country, the purpose of its armed forces is to provide the means --hopefully of last resort-- to establish or maintain control over some geographic area [Ref. 1: p. 17]. Thus, we might define the purpose of a command and control process as follows: "The purpose of the command control process is to either maintain or change the equilibrium state of the environment, as determined by a higher authority" [Ref. 13: pp. 71-76].

In keeping with this definition, it can be said that the purpose of C^2 is controlling the environment in which the commander and his forces are embedded. The concept of "controlling the environment" brings inmediately the idea that the command and control process should be a feedback process to be able of accomplish its purpose.

C. THE MEANS

In order to fulfill its purpose, C^2 has to be composed of interactive elements which are:

- Sensors
- Communications
- Data Processing
- Information Management
- Decision Aids
- Forces To Command
- A Commander

The first five elements are traditionally considered in the C^3 system. In this case, two more elements are added: the forces to accomplish the mission and the commander.

For the C^2 process to function, there must be a single will directing --at least in a macro sense-- the activities of the forces. Therefore, there must be a commander. Secondly, the commander cannot control the environment by himself. His forces must be considered as part of his C^3 system because they provide the means for him to "control" the environment around him. [Ref. 11: p. 62]

A particular remark should be made regarding sensor systems. According to General Robert T. Herres, U.S.A.F., former Commander, U.S. Space Command, sensor systems are either an integral part of a command and control process or are in direct support of that process. Their categorization depends on their functional application at the time of their use and their role relative to the commander's mission [Ref. 14: p. 413]. However, in an elemental manner, sensors give information about the enemy and the environment where the command and control process is embedded. Examples of sensors are:

- Observers
- Patrols
- Optical means
- Electronic means
- Acoustic and thermal detection means

Others will give information about the interior of the enemy's position. They are:

- Ground stations
- Mobile platform stations
- Space stations

Communications link the kind of systems mentioned above with the command post, and connect the command post with others and with the supported units. The links will maintain contact through:

- Wire and cables
- Electromagnetic waves
- Optic fiber, etc

On the tactical level, the C^2 process will use HF, VHF and UHF transmissions. Ultimately, lasers and optical fibers have been applied successfully as transmission mediums.

The commander and his staff will use the data processing means to treat the information they have received and the data that they have stored during peacetime. These means include the hardware: computers, screens, videos, TVs, printers, plotters, etc, and the software needed to support the process.

The harmonious functioning of the means mentioned above presents information in a crude way. Therefore it is necessary to transform this crude information into intelligence. It is here where information management actions intervene to transform the raw

data into useful and coherent information and to orient and coordinate the search for new data. Finally, the decision aids give the commander and his staff an adequate means to evaluate the situations and help the commander in adopting the proper problem resolution.

D. THE C^2 PROCESS MODEL

In keeping with our previous discussion, a convenient model of the C^2 process can be derived by considering it to be a cybernetic system which is attempting to control the environment around it. Such a system is shown in Figure 1. [Ref. 11: p. 64] This is the basic C^2 process model, and it is presented here to clarify the initial stage in the development of more complex models.

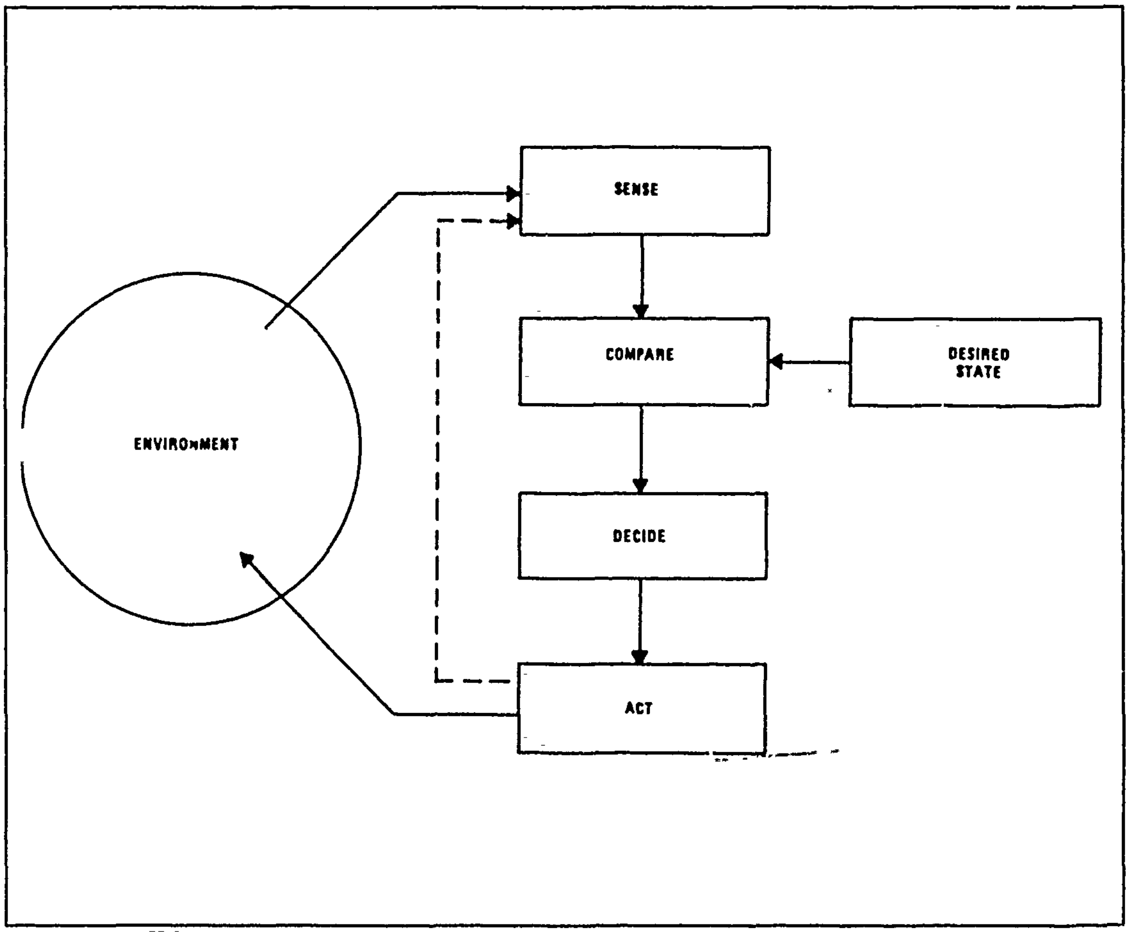

Figure 1. Basic Model of C^2 Process

Basically, the process starts with a sensing of the environment. This is followed by a comparison of the resulting perception of the environment with some "desired state" of that environment, generally established by higher authority. Based on this comparison, decisions are made and actions initiated to bring the environment into closer conformance to the "desired state."[Ref. 11: p. 62] This is a feedback process where the output of the ACT function impacts on the environment and orients the SENSE function.

Lawson's detailed model of the C^2 process is shown in Figure 2. [Ref. 11: p. 65] There are five basic functions indicated, together with their interfaces with the environment. The SENSE function involves all systems and procedures used to gather data from the environment.

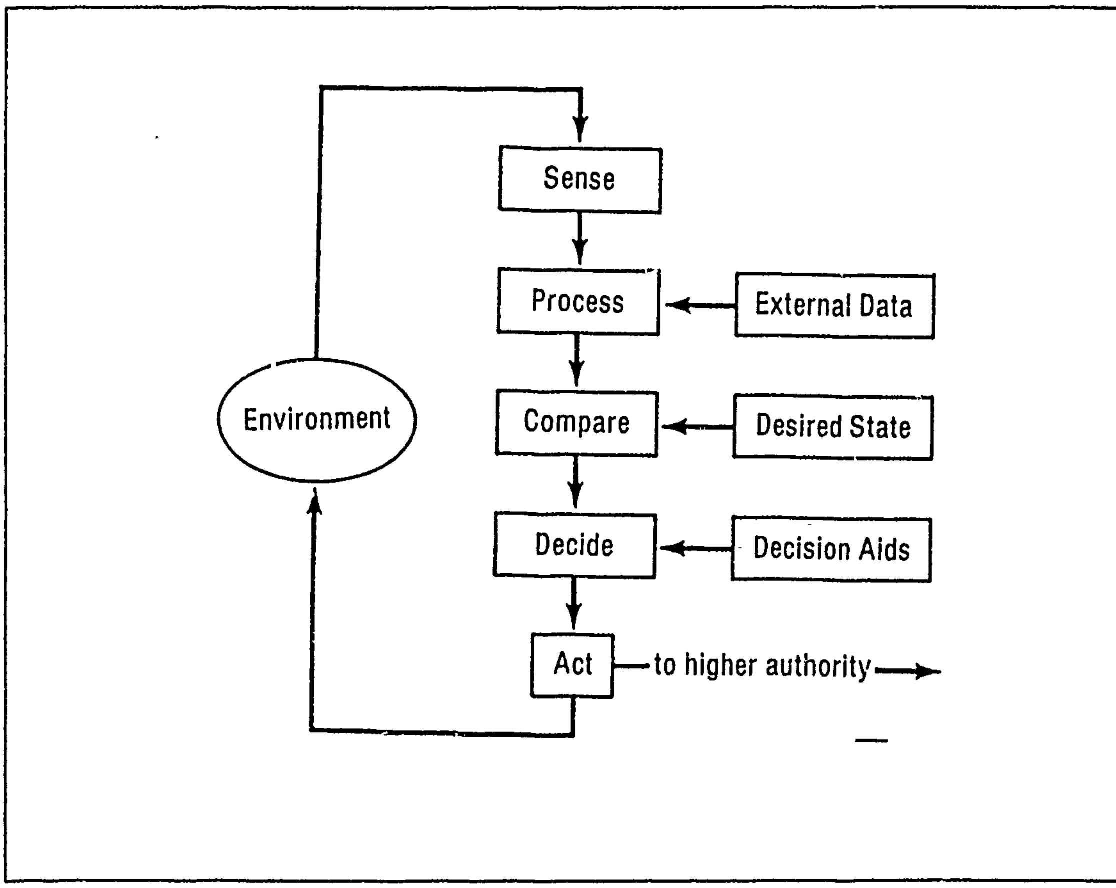

Figure 2. Detailed Model of a C^2 Process

These include different types of sensors, some of which are active (radar, potentially laser), and others which are passive based on physical phenomena (optical, infrared, electromagnetic, etc). The goal of the sensors is to provide continuous coverage of the environment under all conditions. External data, not directly from the environment, may be used.

The PROCESS function involves all the processes and procedures used to deduce the occurrence of specific significant events or situations from the data gathered from the environment. This function produces event reports and status reports for use by later functions.

The COMPARE function compares the state of the environment, as determined by reports from the process function, with a desired state as specified by some external source. Based upon this comparison and with the help of decision aids, the DECIDE function determines what should be done to move the actual state to the desired state, and the ACT function executes that decision. Therefore, the ACT function involves the interface between the system being controlled by the commander or decision maker and the environment. It is the means used to force or influence changes in the environment that are determined to be desirable. The result of acting may produce a change in the environment, which is again sensed, and the entire process is repeated.

This simple model leads directly to the concept of "nesting" such command and control processes, one within another, as illustrated in Figure 3 on page 16. [Ref. 13: pp. 71-76] This is spoken of as a hierarchical structure or the chain of command. The concept of nesting is more descriptive because it emphasizes the interaction of different levels of command at both the "beginning" of the process (sensing of the environment) and the end of the process (the issuing of orders and status reports.)

That is, the superior and subordinate processes go on in parallel, with the major distinguishing feature being the size of the environment they deal with. Presumably the superior process, having a larger environment, will not deal with the same level of detail that the subordinate does. This, of course , may be not true in the case of crisis management, when the highest levels in the C^2 process may have to deal in great detail with some limited region of the world. [Ref. 13: pp. 71-76]

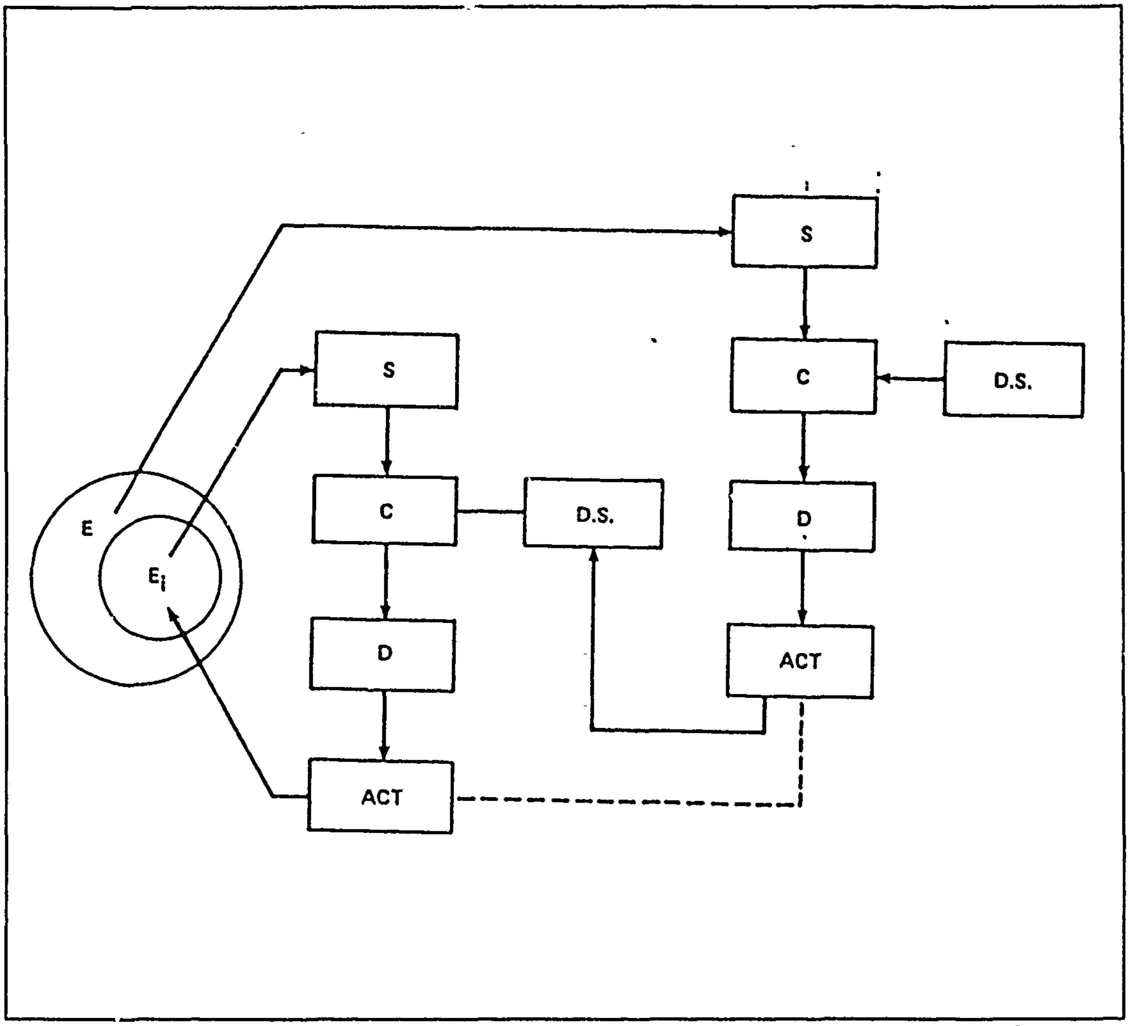

Figure 3. "Nested" C^2 Process

This nested model could be enriched by the existence of more than one subordinate under one superior. This model represents a more complex presentation of the process, but also a more realistic and believeable process, such as is possible in the real world, as stated in the following quotation:

> Participation of several subordinate activities could be reflected, with each of their environments included (possibly with overlap), in the environment of the senior authority. Such a representation could be useful in highlighting the real need for cooperating elements to coordinate their actions. [Ref. 15: p. 6]

Figure 4 describes this situation. [Ref. 13: pp. 71-76] It should be pointed out on this figure that generally a commander's subordinates will share some portion of their environment.

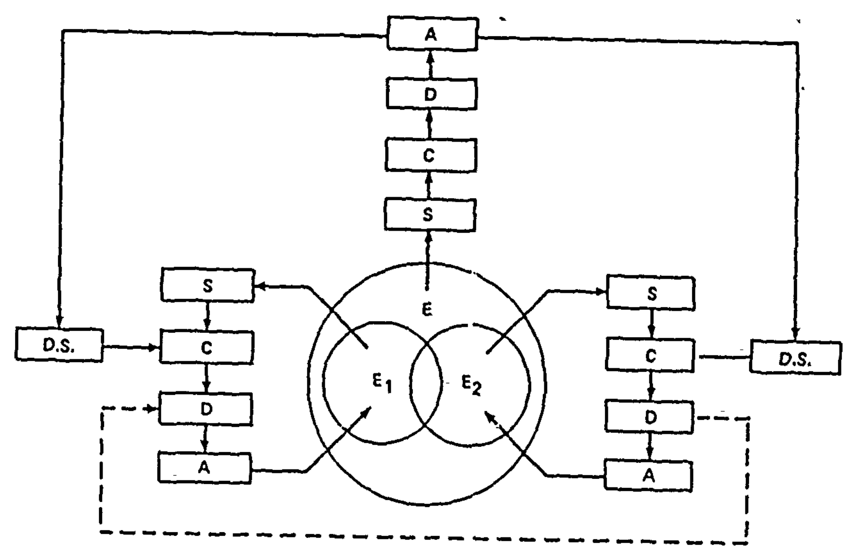

Figure 4. Coordination of the C^2 Process

Therefore, there will be an overlap of the responsibility zones. In this case, it is imposed by the need of the existence of close coordination between the superior and his subordinates. The role of the commander is, in such a case, to monitor and control the interface between his subordinates as their common superior.

The process introduced so far appears very much like an "intelligence process," but the outstanding difference is the fact that the intelligence process does not care about the desired state. It attempts to predict the future based on both past facts and the present state of the environment. This process goes on in parallel with the C^2 process,

but there are several differences that obligate the commander to be careful in the treatment of the interfaces between both processes.

E. SUMMARY

This chapter is designed to establish a commonly understood definition and description of the C^2 process. The purpose of the process has been introduced along with the means to support the process. Figure 1 on page 13 depicts the process in a very simplified form showing the most important characteristics in order to allow a discussion of the architectural features. The detailed model permits observation of the interactions with the external world. This leads directly to the concept of nesting of one C^2 process within another C^2 process. Finally, the coordinated process is shown in a model which is closer to reality than the previous models introduced thus far.

IV. THE COMBAT OPERATIONS MODELS OF C^2

A. INTRODUCTION

The last chapter introduced the main characteristics of the C^2 process and showed its purpose and the means it uses to reach its goals. Also introduced were different models of this process. As a continuation of the information previously explained, this chapter will develop the C^2 process and its application to military operations through the combat operations process model. The intelligence analysis task, inherent to this process, will be developed in some detail.

B. THE LAWSON C^3 I PROCESS MODEL

The basic command and control model, developed by Lawson and introduced in the previous chapter, is expanded to take the intellegence function into consideration. It is shown in Figure 5 on page 20. [Ref. 16: p. 26]It can be seen that the right side of the model conforms to what was developed in the previous chapter. The left side is what is new in this model and is called zone I (intelligence zone).

In the SENSE function, the data received from any level of command are analyzed to see what the enemy is doing and what it is trying to do. This data comes from the environment through the sensors once the action is in progress, hence these systems are for combat situations.

The PROCESS function determines the options that the enemy has available to him to carry out his intentions. Because there is insufficient data to specifically identify which option the enemy will choose. this function will tell the previous function "what" and "where" to sense. The COMPARE function analyzes the new data received to reduce possibilities and compares the actual situation with the desired state of the environment.

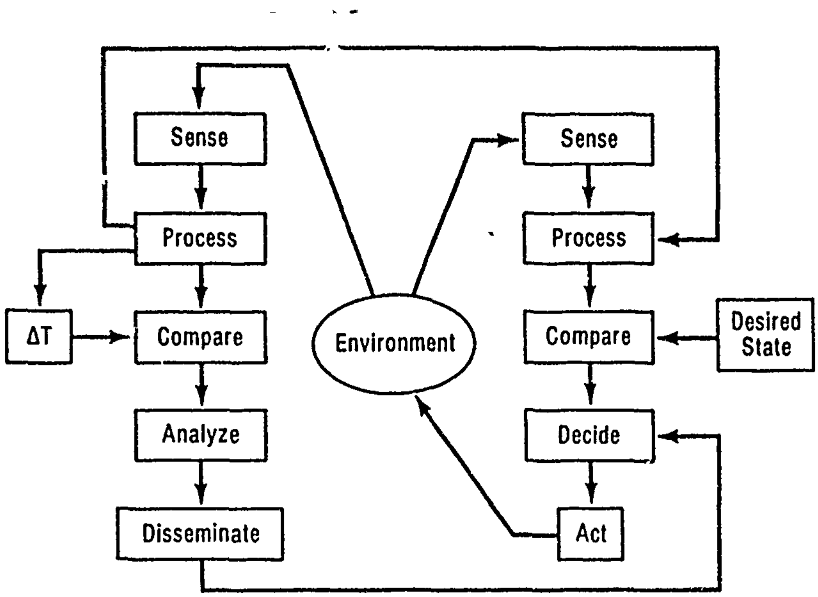

Figure 5. Lawson's C^3 I Process Model

The ANALYZE function is a key step in this process. The reduced possibilities are transformed into hypotheses. These hypotheses are used as the basis to elaborate plans. A better understanding of this function can be obtained through the Combat Operation Process Model developed in the next section.

Finally, the DISSEMINATE function distributes the data transformed in intelligence to every unit in the chain of command. This intelligence could affect the decision adopted, and in such a case could modify that decision.

Lawson emphasizes that projections (indicated by the Delta T block) should not be used by the C^2 process except as part of the DECISION process. The reason for this is his fear of creating unstable systems. [Ref. 16: pp. 23-43]

Looking at lines between blocks reveals that this is a feedback process. As was said before, this is a dynamic closed loop, where the final outcome of a function, through the environment, affects the entire process, thus creating a new situation that affects the SENSE, PROCESS, and DECIDE functions. The PROCESS function provides for error reduction --the difference between the real situation with the desired state-- to zero, through the feedback action.

C. COMBAT OPERATIONS PROCESS MODEL

Figure 6 shows the Combat Operation Process Model. This model is presented by George Orr in his "Combat Operation C^3 I: Fundamentals and Interactions." The following is a brief explanation of the main characteristics of this model. [Ref. 16: pp. 23-43]

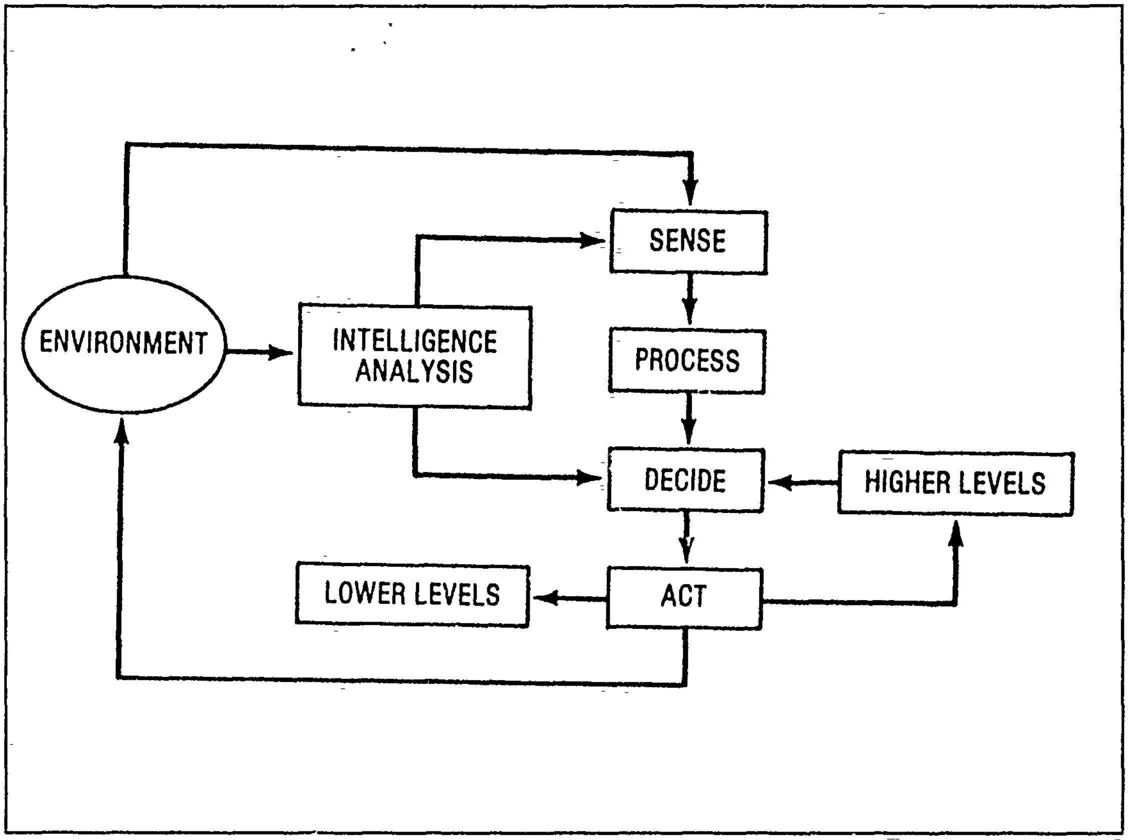

Figure 6. Conceptual Combat Operations Process Model

The Orr model includes the INTELLIGENCE/ANALYSIS function block with interfaces to several of the other functions of the process. This function is not very important at the lower levels where the direct action affects the environment immediately, but at higher levels in the hierarchy, the INTELLIGENCE/ANALYSIS function begins to be identified as an individual function. Such is the case in the Lawson C^3 I model under all conditions. The key items of this function are coverage and timeliness.

The PROCESS function, in this case, is guided by the INTELLIGENCE/ANALYSIS function. Indications from many sensors are gathered and used to match patterns known to indicate specific situations or events. This function provides the commander with the information that enables him to "see" the battlefield. The dynamic nature of the battlefield results in a dynamic intelligence perspective. Then, raw data from sensors plus intelligence and analysis reports are transformed by the PROCESS function into the event and status report, which is necessary to the next step, the DECIDE function.

The INTELLIGENCE/ANALYSIS function includes two principal activities: the search or collection of information, and the forecasting of changes in the current situation. The search or collection of information concentrates on gathering information about the enemy from all the sources available. The sources may include tactical, strategic and national systems which provide human intelligence, electronic and signal intelligence and overhead imagery intelligence. These sources will provide information about the organization, structure, capabilities, vulnerabilities and intention of the enemy forces. Previous available information about political, economic, social, ethnic and other non-military matters is also important. The forecasting of changes in the current situation is related to the identification of probable courses of action and the determination of enemy intentions. This activity is critical in the decision making process. The forecast produced by the PROCESS function is required by the combat commander and staffs to make confident decisions based on the knowledge of terrain, weather and the enemy's activities and capabilities.

The forecasts developed by the INTELLIGENCE/ANALYSIS function orient the SENSE function by indicating where to look and what to look for, orient the PROCESS function in the developing of patterns for events and situations, and orient the DECIDE

function by providing an adequate forecast of events and situations and giving an evaluation for possible consequences of proposed actions.

The DECIDE function is, per se, extremely complex. Given the dynamic nature of war, this difficulty is severely magnified. General Donn A. Starry, U.S.A. (Ret.), a noted military leader and historian, has described today's decision making process:

> The command and control problem goes something like this: In order to fight the battle successfully, the commander has to find out what is going on, decide what to do about it, tell somebody what to do, then keep track of how the battle is going. He needs to turn that information-decision cycle in time inside the enemy's information-decision cycle so that, instead of simply reacting to what the enemy does, he can seize the initiative. [Ref. 17: p. 7]

There are a number of reasons why the DECIDE function is by far the most difficult in the whole process. A fundamental reason is the nature of the problem as stated below:

> When the game he (the commander) is playing is continually subject to unpredictable change, there is simply no information technology that can be called upon to cast the commander's problem in the form of a set of binary choices.
>
> The crux of the matter is that our commander must deal with contingencies. Each contingency is a choice-point, and the possible paths ahead at any moment ramify so rapidly that detailed pre-planning that is adjusted to contingent events is literally impossible. [Ref. 18: p. 20]

One reason for the complexity of the DECIDE function, especially for the Army, is that the land combat, tactical, evaluate-decide process is far more human-oriented than any other form of warfare. Decision making is heavily dependent upon information and knowledge which cannot be quantified or symbolized. Some examples of these factors are abstract tactical principles such as fire and maneuver, the host of psychological and physiological intangibles which influence mens' actions on the battlefield and determine what is possible or not possible in any given situation or instant of time, the commander's own intuition of what will succeed or fail, and his stored prior experience which he brings to bear on the problem. The human mind provides the most effective C^2 system found in nature. Human psychology cannot be ignored in dealing with any decision making process because every C^2 system, ultimately, has to interface with the man.

On the whole, human decision making is remarkably good, showing great robustness and flexibility. There is, however, evidence of systematic bias in subjective judgment which can present significant problems. Proposed automated decision making aids are sometimes designed to compensate for these systematic biases in human judgment.

On the other hand, there are other aspects which have to be taken into account on this subject to complete the description of the decision making process. Over time, the ability of the intelligence sources to provide data on the progress and status of operations is increasing rapidly and continues to grow at an unbounded rate. In conjunction with these advances in sensor technology, the services are successfully developing systems to perform data correlation and fusion which transform and reduce the inordinate amounts of data into valuable information. This resulting information, however, is still too voluminous for a human decision maker to manage. Combine this with the increasingly complex task of managing today's sophisticated weapon systems, and it is obvious that the human decision maker is too overwhelmed to make consistently sound judgments based on this information. Another alternative to consider is that when human decision makers are put into a stressful situation and are forced to make time-critical decisions, behavioral changes can result. They may not seek optimal solutions to C^2 problems. [Ref. 19: p. 44]

The last block to consider is the ACT function. The main characteristic of this function is that it interfaces with the environment to bring the situation to the desired state. The commander or decision maker triggers the action, and the means used are the available forces. In fact, the general model applies also to political, economic, industrial, etc., situations in which the system interacts with the environment in order to control it.

D. C^3 FUNCTIONAL TASKS

C^3 has two general requirements --information and action. Information is necessary for planning and formulation of command decisions and monitoring the execution of directives; action occurs in issuing and implementing directives [Ref. 4: p. 20]. JCS memorandum 3-82 [Ref. 20] outlines the functional tasks for the C^3 systems supporting U.S. forces to accomplish these requirements. The functional tasks are listed below.

They can have some strategic flavor, but it is convenient to say that they apply equally to theater and to tactical levels :

1. **Monitoring the situation**

The C^3 system will monitor the current situation, including the status of U.S. and non-U.S. forces. This is the process of sensing critical information concerning the political, economic, and military situation on a worldwide basis. The process requires all-source information collection and processing to recognize unique events and to identify changes in the status of U.S. and non-U.S. force capabilities in the politico-economic environment.

2. **Formulating responses**

The formulating responses task includes warning and threat assessment. This task also comprises evaluation of enemy intentions, current enemy capability to carry out intentions, and the selection, adaptation, or formulation of plans responsive to the specific situation.

3. **Selecting Options, Employing Forces, and Executing Operation Plans.**

For deterrence, this is the process of perceiving the pattern of enemy response to U.S. activity and assessing the impact of U.S. activity on the enemy posture and capability to initiate hostilities. For force employment to control escalation, the process includes selecting appropriate responses, implementing operation plans, perceiving the changes in patterns of enemy response to U.S. activity and assessing the impact and effectiveness of U.S. activity in terms of the enemy response. For force employment in response to hostilities, the process includes determining and directing U.S. force activities in response to tactical warning and recommending an appropriate response based on attack assessment.

4. **Performing assessments**

The performance of attack assessment includes the process of deriving projected attack patterns and impact points from sensed attack events to determine the character and expected effectiveness of an attack. The performance of strike, damage, and residual capability assessment includes the process of acquiring strike and damage reports, correlating them to provide a perception of the extent of damage to friendly and enemy

forces, and evaluating the impact of damage upon enemy and friendly force residual capabilities and resources.

5. Reconstituting forces

This process includes acting on status reports concerning the location, condition, and availability of military resources after attack. The process includes reviewing the progress of directed activities and planning subsequent force employment options based on damage assessment and residual capabilities.

6. Terminating actions

This is the process of perceiving a willingness on the part of the enemy to negotiate termination of hostilities, projecting the results of current U.S. and enemy activity, and assessing enemy intent and residual capability. The process includes developing plans for recovery and redeployment to deter renewed conflict and monitoring the achievement of the directed recovery posture to insure that the conflict terminates under conditions favorable to the U.S.

E. FUNCTIONAL CRITERIA

To achieve these functional tasks, military C^3 systems need to meet the following criteria[Ref. 1: p. 20]:

1. Interoperability

Systems, units, or forces must be able to provide service to and accept from other systems, units, or forces and to use the services so exchanged. [Ref. 21: p. 182] Because of the need to operate with other services and allies, interoperability is a major issue. This involves questions of standards, commonality, compatibility and interfaces. [Ref. 22: p. 77]

2. Survivability

In a battlefield environment, systems fail for a variety of causes. Equipment can be damaged by fire, dirt and dust. Circuit boards and wires can be corroded because of rain or salt spray. Connections can be separated by extreme cold or heat, or vibrations or shock. It is indeed a very rough environment for electronic material. In order to survive the environment just described, both command centers and the communications

that link one with another and with the operating forces must take some preventive measures: dispersal of key facilities, mobility, hardening against enemy weapons effectiveness, and redundancy of key facilities, communications, and information data bases. [Ref. 23: p. 181]

3. Reliability

A system should do what it is designed to do all or a very high percentage of the time. This is achieved by designing and acquiring equipment with low failure rates, employing error correcting techniques, maintaining redundant resources for key system components, establishing alternate communication routing, and eliminating sources of human fatigue.

4. Flexibility

To meet the challenges of changing situations and diversified operations with a minimum of disruption and delay, C^3 systems must be designed to be easily changed and reconfigured. [Ref. 24: p. 11]

5. User-orientation

Information must be readily accessible in a form usable by the commander and his staff. Displays, graphics and decision aids should not require extensive analytical interpretation. [Ref. 1: p. 22]

F. SUMMARY

This chapter is designed to describe the combat models developed for executing the command and control of engaged military forces. Through the PROCESS, COMPARISON and ANALYSIS functions, the loop is completed to obtain a real picture of the situation and orient the functions in order to optimize the commander's view of the battlefield. The INTELLIGENCE/ANALYSIS function is highlighted in the Combat Operations Process Model. This function acts like a guide in orienting the rest of the functions in the always-changing environment of war. DECIDING is the most complex of all the functions. Its complexity is based on the human nature of the involved elements of this function. Decision making aids are used to help in this function, but it is the commander who imposes his style in using these aids. Finally, the C^3 functional tasks were listed --as stated by JCS-- in order to accomplish both the information and action

requirements of the system. The required capabilities of C^3 systems were listed in this chapter.

V. THE ARCHITECTURES

A. INTRODUCTION

Controlling and optimizing today's advancements in information management technology is critical to achieving a true operational balance in any army. An appropriate handling of information by users allows the army to perform its functions better. Providing fire direction data from forward observers to artillery battery fire direction centers or ensuring the timely alert of short range air defense gunners to improve their probability of successfully engaging a target are two examples of how suitable information management impacts on the development of military actions.

The overall information management goal is to design, build and field C^3 systems and to support systems so that the army can operate the same way in peacetime as during war. To achieve the optimal development of a C^3 information system, it is necessary to give a reference frame from which to work. This reference frame is usually called an information architecture, and this concept is extended in the following sections. Most authors of this subject utilize the term C^3 architecture instead of C^2 architecture. Therefore, for a more convenient understanding, the terminology C^3 architecture will be used in this chapter. This also applies to C^3 system instead of C^2 system.

B. THE INFORMATION SYSTEM ARCHITECTURE

The information system architecture defines the relationship of all elements involved in information management and provides a blueprint for planning, developing and executing initiatives to enhance battle management. The architecture at each level blends together the information requirements of the tactical, theater, strategic and sustaining bases arenas. The architecture provides a basis for identifying, validating and placing in order of priority the information requirements to facilitate a systematic approach for acquiring future resources, while precluding development of unnecessary or redundant information systems and encouraging sharing of the information resources. [Ref. 25: p. 12]

One of the main challenges in the development of this architecture is how to move from traditionally separated telecommunications systems (information transfer) and computer (information process) systems cultures to a modern information oriented system. To deal with this problem, the new emphasis is on the establishment of an information system architecture that will accommodate the growing volume of information processing and transfer needs, yet ensure compatibility, interoperability, speed and security in command and control. The architecture is intended to accommodate the administrative and management functions of the users while providing rapid and expandable information transfer for Army missions. [Ref. 26: p. 195] The Information System Architecture offers the appropriate frame for the development of a C^3 architecture, which is examined in the next section.

C. C^3 ARCHITECTURE

The architecture of a C^3 system is the initial stage of an overall system engineering process. As the highest levels in the national leadership increasingly tend to reach down through the hierarchical military structure to control forces -- sometimes focusing deeply in a small area, particularly in crisis situations management-- it can be said that the process is described as one C^3 layer supported by layer on layer of C^3 subsystems. LTGen. John Cushman, U.S.A. (Ret.), a broadly experienced commander and a specialist in C^3 , states that an organization's C^3 is a subset of the C^3 of the superior military organization to which it belongs. [Ref. 27: p. 21]

The C^3 architecture can be defined as the arrangement of (or process of arranging) the basic elements of C^3 into an orderly system framework. The singular characteristic of a C^3 architecture is that it describes the interrelationships between selected elements of command and control. The command and control elements considered in this case are functions, facilities, equipment, communications, procedures and personnel. The C^3 architecture will be expressed as a set of assumptions, statements and diagrams describing the interoperation among the elements of C^3. [Ref. 28: p. 81]

The former Deputy Under Secretary of Defense for Command, Control, Communication and Intelligence, Don Latham, expressed his point of view about C^3 architecture in the following way:

> Different people have different views of what architecture really is . . . Too often, people look at C^3 I as a parts list rather than being able to articulate it into some sort of a framework. When I start talking about program A, B, C and D, I try to develop a framework on which to hang systems A, B, C and D. This is really where you need architecture, that is, the system approach or system framework. [Ref. 29: p. 7]

Figure 7 illustrates the comparison between the military information system and the C^3 system. This figure shows the overlap between the two systems at the highest levels of decision making. The C^3 system employs the information that the commander and his staff need to make decisions accurately and on time. The information system architecture and the C^3 information system architecture must reflect this condition.

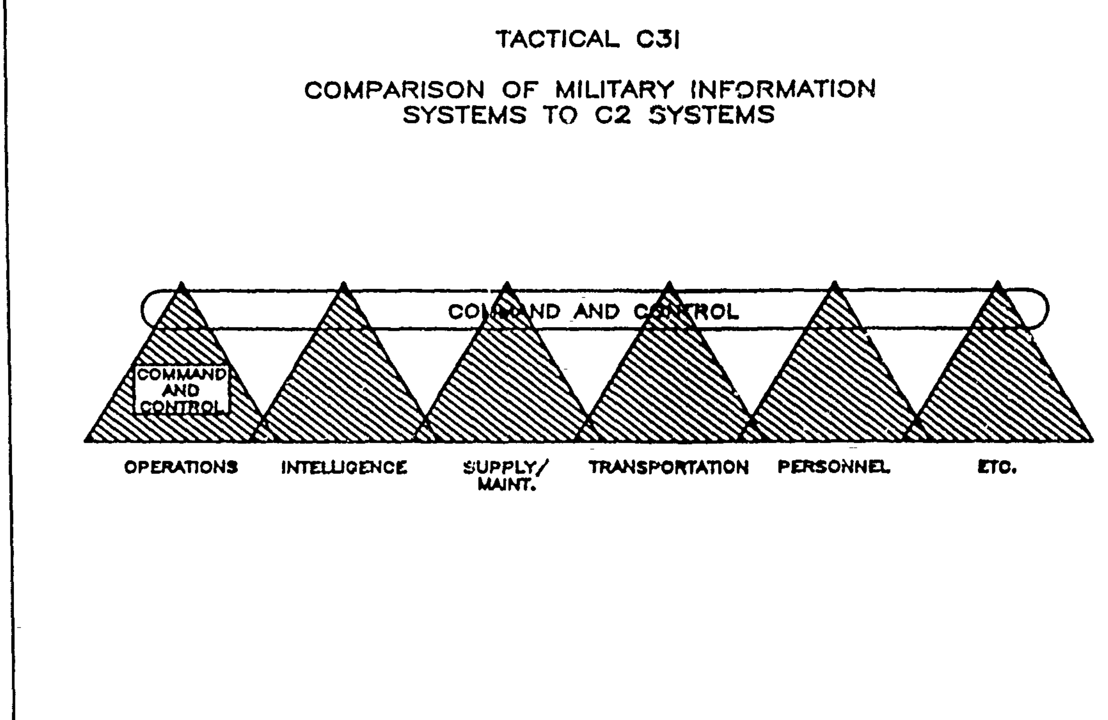

Figure 7. Comparison of Military Information System to C^2 System

D. TACTICAL C^3 ARCHITECTURE

This section describes briefly the C^3 architecture adopted by the U.S. Army, focusing on the system in the tactical arena. To modernize information management, the U.S. Army has redefined and readdressed its information systems at all levels. Figure 8 on page 32 illustrates the SIGMA star, which represents the Army's five basic functional areas: maneuver (MVR), fire support (FS), air defense artillery (ADA), intelligence/electronic warfare (IEW), and combat service support (CSS). These processes are automated or manual, and they are designed to support the internal technical mission of the battlefield functional areas. The systems are the combination of transmission and processing systems. However, some of them appear as pure transmission or pure processing systems.[Ref. 30: p. 205]

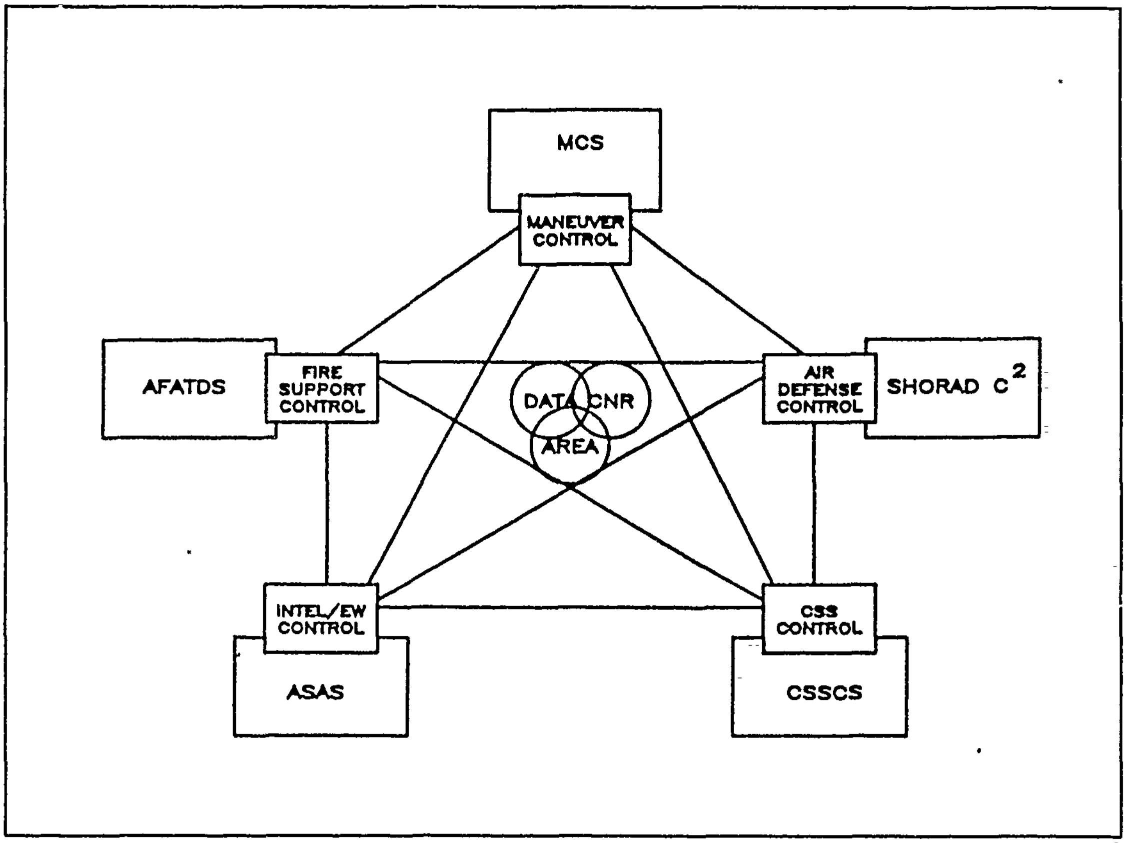

Figure 8. Army Tactical Command and Control System (ATCCS)

All of the battlefield command and control activities can be associated with the particular functional segments mentioned above. The following is the description of each functional segment given in the Ninth Annual Symposium of AFCEA. [Ref. 29 : p. 7]

1. Maneuver Control

The maneuver control area comprises the facilities employed to plan, direct, coordinate and supervise the combat activities of a combined arms force as it closes with and destroys the enemy by use of fire and maneuver. This includes the command, control and coordination of combat, combat support and combat service support elements of the forces in accordance with the commander's scheme of maneuver.

2. Fire Support

The fire support area comprises the facilities employed for command, control and coordination of activities related to surface target development and the weapon systems and munitions available to engage those targets in order to suppress, neutralize or destroy them in support of the force commander.

3. Intelligence/Electronic Warfare

The intelligence electronic warfare area comprises the facilities employed for command, control and coordination of activities related to intelligence collection, combat information development, operations security and electronic warfare.

4. Air Defense

The air defense area comprises the facilities employed for command, control and coordination of Army activities related to air defense management and the weapon systems and munition available to destroy airborne targets in support of the force commander.

5. Combat Service Support

The combat service support area comprises the facilities employed for the command, control and coordination of the activities related to logistical support, personnel administration and soldier support available for the execution of those functions in support of the force commander.

E. SYSTEM TYPES

Three forms of tactical communications systems are required to support the Army's tactical command-control systems as illustrated in Figure 9 on page 34. [Ref. 30: p. 205] These types of systems are as follows:

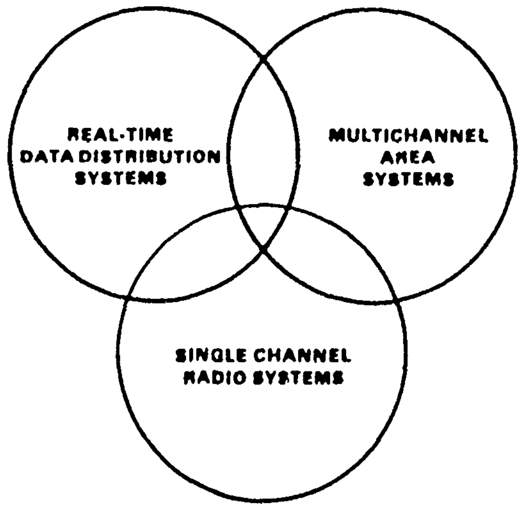

Figure 9. Communication/Data Distribution for C^3

1. Army Data Distribution Systems

This class of communication system includes the special system designed primarily to accommodate the near real-time transmission of data, record and graphics traffic. [Ref. 30: p. 205] These systems meet the high speed data requirement for low volume data to provide quick sensor-to-shooter reaction time. [Ref. 25: p. 12]

2. Multichannel Area Systems

The multichannel, circuit-switched area communication systems are required throughout the area of operations to accommodate high volumes of traffic in all nodes (i.e., voice, record, data and facsimile). The area systems provides the primary means of secure communication at all echelons behind battalion. This multichannel system is evolving from analog to digital technology. This system is also referred to as Area Common User and provides broad area coverage for commanders and staffs. [Ref. 25: p. 205]

3. Single Radio Channel System

This class of communication system includes the HF, VHF, and UHF combat net radio systems, UHF and EHF single channel tactical satellite systems, and the dedicated data link used to satisfy special purpose communications or data distribution requirements. Although used at all tactical echelons of the U.S. Army, this class of communications system represents the primary communication mode at battalion level and higher.

It should be mentioned that voice communications are still needed on the battlefield. Most commanders derive important situational clues by listening to how their subordinates sound in their verbal reports.

F. THE AIR-LAND BATTLE AND C^3

At this point, it is appropriate to briefly develop the concept of the AIR-LAND BATTLE. This is actually the official doctrine of the U.S. Army, and the reason for introducing this concept here is the fact that C^3 architecture is evolving in accordance with this doctrine's principles. This doctrine imposes on the future battlefield command and control new methods for treating one of the most valuable and perishable assets of any army: information.

Over the last few years, the need for the U.S. Army to develop new battlefield concepts capable of meeting the threat posed by its enemies has led to a major revision in military doctrine. This doctrine would allow the U.S. to win tactically by incorporating the greatest technological strength of the U.S. industrial base: the use of information. [Ref. 31: p. 231] The Air Land Battle is fought by what is called theater forces. It means

that the land and tactical air forces are those which would fight the Air Land Battle in a land mass theater. Figure 10 on page 36 shows this structure. [Ref. 17: pp.3-25]

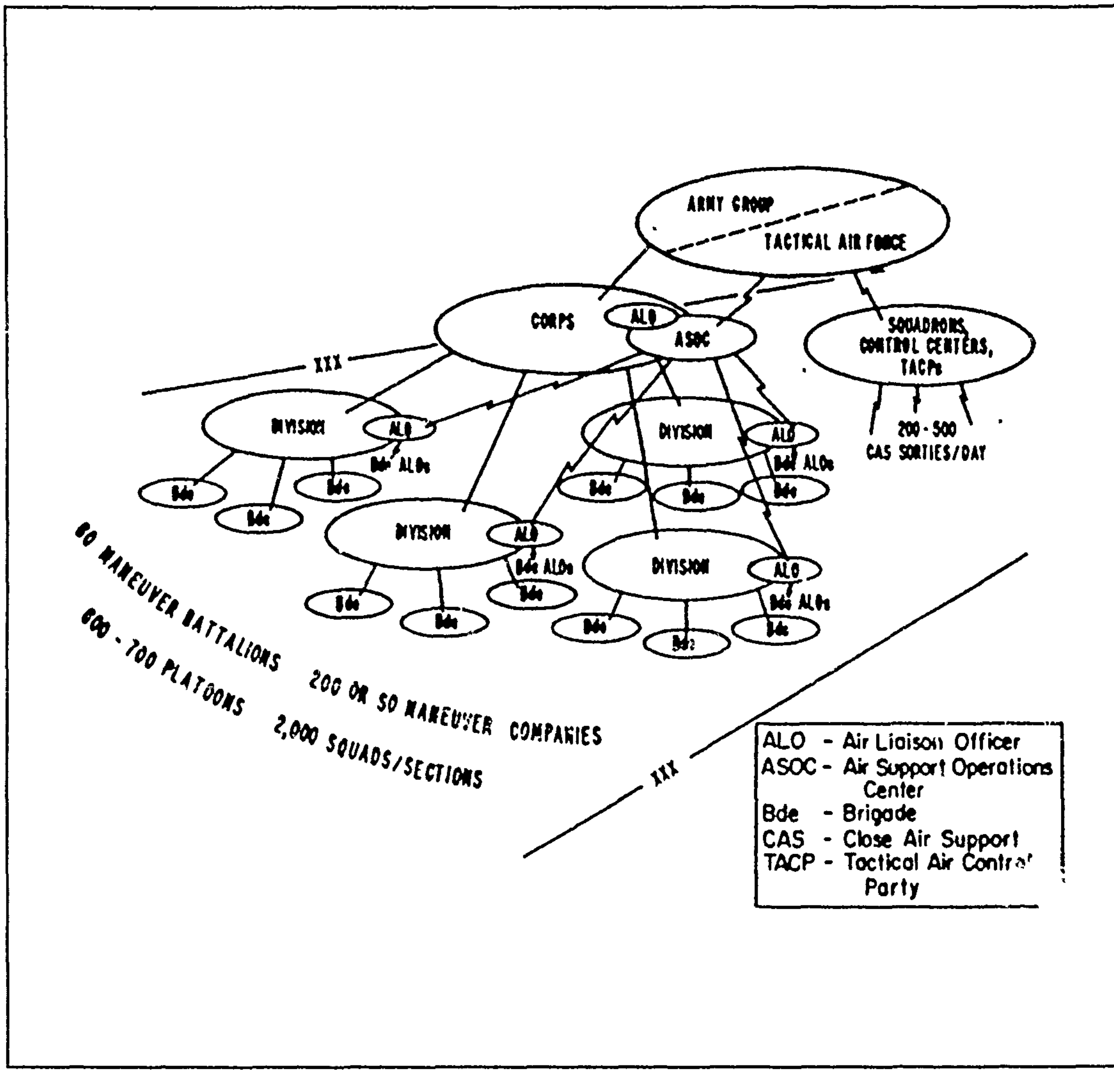

Figure 10. Air Land Battle System

In its bare chain-of-command skeleton, the Air Land Battle system can be looked upon as an army corps, with its subordinate units arrayed on the battlefield, and with its accompanying tactical air. At each combined arms echelon --from corps to company, and even below-- the Air Land Battle system is a mix of functional systems or subsystems as shown in Figure 11 on page 37. [Ref. 17: pp. 3-25] The way that these subsystems operate changes with different situations and different commanders. Fighting

styles often differ markerdly, even in the same army.[Ref. 32: pp. 45-51] Therefore, it is the commander who has to adapt his C^3 system to his own style.

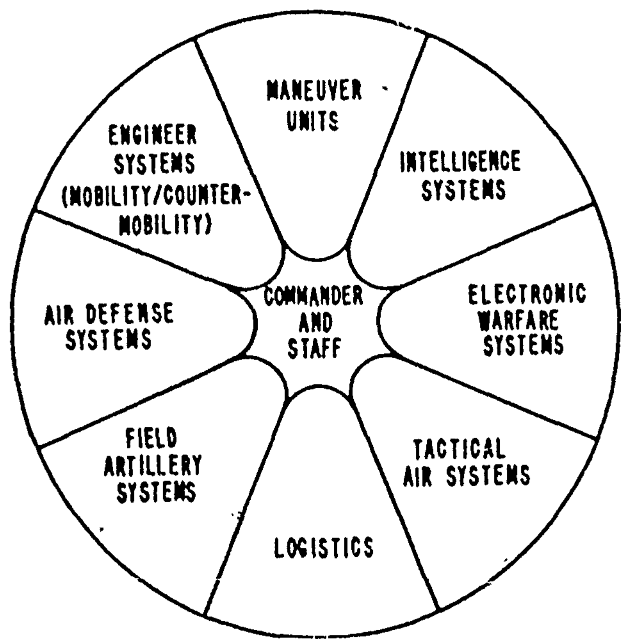

Figure 11. The Mix of Functional Systems

The Air Land Battle's most salient feature is maneuver. The objective is to concentrate or disperse forces and combat systems more rapidly than the enemy can react and thereby create opportunities to seize the initiative and to destroy the enemy's ability and will to fight. The concept envisions synchronized but decentralized battle execution by relatively small, self-sufficient units which blend intelligence, firepower and movement into continuous operations to see and strike to the critical depths of enemy formations. [Ref. 33: p. 31]

The C^3 system operates in the Air Land Battle environment in conditions often approaching chaos. An armed and thinking enemy is using all his means with all the skill he can muster to defeat the commander's forces. The skills and leadership of commanders and the quality of staffs are usually decisive in such situations. Good commanders try to simplify and to reduce the load of their communications by cutting down on message traffic, that is, by reducing the number of words sent over communications networks. Commanders, among other things, will try to achieve the following:

- A common perception of the situation
- A common understanding of the mission
- A common understanding of how to operate
- Teamwork through experience [Ref. 34: pp. 3-25]

The principles impose on C^3 systems particular characteristics. Implicit in the Air Land Battle concept is the need for mobile networks, a communication resource of high reliability and survivability in the face of hostile enemy action.

G. BATTLEFIELD INFORMATION SYSTEMS

Tactical command and control is evolving into a single integrated battlefield information system with four primary functions: information transport, information management, information collection and information denial. For information transport, the Army must integrate voice, graphics and imagery within the information system on the battlefield so that scarce communications resources can be used wisely. As the technology is evolving from voice to data transmissions, it is necessary to take advantage of the package technology. One of the key characteristics of information management will be the existence of distributed networks overlaid on the information transport system. Information collection systems consist of sensor and data processors that provide integrated intelligence and real time targeting information. In the information denial area, the army will need to employ jamming, self-protection and deception to enhance combat effectiveness.

H. SUMMARY

This chapter is designed to describe the concepts of the combat information system architecture. The establishing of this architecture is essential to the development of C^3 systems. It gives the reference frame for any particular project in the information system area. The tactical information system architecture is designed to support the battle functions in five major areas: fire support, maneuver control, air defense artillery, intelligence/electronic warfare, and combat service support. Finally, it was pointed out that tactical command and control systems are evolving towards integrated information systems.

VI. COMMAND AND CONTROL IN THE ARGENTINE ARMY

A. INTRODUCTION

So far, the main concepts of C^2 and C^3 have been explained, particularly their definitions, processes and architectures. But now, the viewpoint will be concerned with the first steps to establish such concepts by the Argentine Army in the C^3 arena. A general description of the actual state of the Argentine Army C^3 Project will be presented in this chapter, and some guidelines and comments will be given about its possible evolution. As part of this introduction, a few words are necessary to prevent the reader from misinterpreting certain events that occurred in Argentina during the last years. A good description of these realities is given by a group of naval and military Argentine officers in an article published in *Proceedings* (March 1989) as follows:

> Most of the world has not fully understood what Argentina suffered in the recent past. The republic faced a strongly ideological terrorist aggression . . . The nation returned to democratic rule in 1983. The 1982 conflict with Britain for control of the Malvinas (Falklands) Islands disturbed the foundation of Argentina's relations with the Western alliances. Indeed, although its culture and history place the nation unquestionably in the Western world, the troubles of the last years have progressively isolated Argentina from Western foreign policy . . . . Now that is changing. Argentina has been emerging from its isolation, attempting to match its interests with the global interests of the West and to demonstrate that its foreign policy is rational and predictable. It is imperative that these efforts succeed, for Argentina occupies a vital location in the strategically important South Atlantic . . . .[Ref. 35: p. 59]

The Argentine Army (AA) was deeply involved in Argentine national political activities from 1976 to 1983, and meanwhile it fought in Argentine interior and foreign conflicts mentioned above [Ref. 36: pp. 28-39]. After those turbulent years, the Argentine Army is evaluating its doctrine, capabilities and vulnerabilities in order to be able to accomplish the mission imposed by the Constitution of the Argentine Republic. One of the areas where the Argentine Army is most concerned is C^3 systems. Past experience has demonstrated some inadequacies in the proper management of battle and crisis situations. In the excellent book *Operaciones Terrestres en las Malvinas*, written by officers who participated in the campaign, Colonel F. Aguiar (Argentine Army),

Colonel F. Cervo (A.A.), Colonel F. Machinandiarena (A.A.), Colonel E. Dalton (A.A.) and Colonel M. Balza (A.A.), objectively described the battle for Puerto Argentino (Port Stanley) and arrive at the following conclusions:

> The knowledge of the situation was always fragmentary and insufficient; it made difficult the right and timely adoption of resolutions by the Tactical Command operating in Puerto Argentino.[Ref. 37: p. 183]

Another part of the book highlights the good performance of other elements where command and control worked properly:

> The centralization of the field artillery units at high levels of battle management made possible the execution, coordination and control of fire support during the development of actions . . . . The communication troops, in spite of limited resources, linked command and units, installed fire support networks, and held links with continental Argentina permanently.[Ref. 37: p. 189]

Several measures were taken by the highest authorities of the A.A. in the last few years in order to develop C^3 doctrine subject to limitations imposed by budgetary considerations. The following sections describe the current state of these developments.

B. BACKGROUND

The general concept of command and control is implicit in the Argentine Army's doctrine, but it is not an explicit doctrinal issue within the army. Said another way, the words "command and control" have begun to appear in Argentine military literature recently, but concepts and principles are still not incorporated in the doctrine.

The different problems introduced above obligate the military to concentrate its efforts in many areas besides its primary function. For this reason, command and control has not evolved in the Argentine Army in the same way it has elsewhere.

The last important Argentine Army's doctrinal update took place in the middle 1960s when the exellent relationship between Argentina and United States made possible a good exchange of information, particularly in organizational and procedural subjects. After those events, Argentina in general, and the Argentine Army in particular, suffered from isolation from the rest of the western nations.

Command and control processes and command, control and communications systems have not been recognized entities in the Argentine Army in the same manner as they are in the U.S. Army. For this reason, it is very difficult to identify the real problems that the Argentine Army has in its command and control process.

The Argentine Army is currently involved in an in-depth review of its warfighting policies and procedures. This provides an ideal opportunity to incorporate the concepts of command and control into army doctrine. To do that, the C^2 process should be carefully studied and adapted to the unique requirements of the Argentine Army. Such a study would have to center around the command and control process itself. Knowledge of the process is fundamental for further development of a commnad, control, and communications architecture.

The Argentine Army Chief of Staff ordered a study about C^3 aspects in 1989. Among the documents used to regulate command and control activities within the Army up to that moment were the following:

- The manual "Organization and Functioning of the Staffs" contains current doctrinal issues in its chapter named "Operations Control."
- The report and proposal worked out by the Special Studies Team (C^3) in 1987.
- Directive of the Chief of Army General Staff 726/89 (Development of the C^3I Project) dated 11 May 1989.
- Report about defining the mission, functions and capabilities of the C^3 I system written by the C^3 Department/ Planning Direction in conjunction with the J3-Operations in June 89.
- Information about various foreign C^3 system developments, in particular the RITA from France, CATRIN from Italy, EPLRS and ATCCS from U.S.A.

With the documents mentioned above as background, the recently created C^3 Department of the Argentine Army Staff made two major reports about the characteristics of a possible C^3 architecture for the Army: the C^3 System Study and the C^3 Command Center Study. Both studies will be described briefly.

1. C^3 SYSTEM STUDY

The C^3 System Study established the operational requirements considered necessary for the Argentine Army C^3 architecture. They were the folowing: [Ref. 38: pp. 5-17]

- Provide warning about enemy attacks and describe magnitude and type.
- Provide permanent evaluation of the current situation of own forces.
- Collect information about the potential enemy threat in order to formulate analysis and evaluation of the current situation.
- Assist planning support and decision making process.
- Transmit orders and control the mission execution.
- Coordinate actions in time and space.
- Protect and secure the stored and transmitted information.

In order to satisfy the requirements listed above, the C^3 Department proposed the implementation of four subsystems:

- The High Reliability and Survivability Communication Subsystem (COMTAC) which has the objective of offering fast, secure, and continuous communication support to all the operative units, as far as battalion and company levels, and link the tactical system with the national and strategic communication system.
- The Target Acquisition and Battlefield Surveillance Subsystem (VICATAB) which has the objective of acquiring land targets, processing the data obtained by the sensors in the data correlation centers and supporting the field artilery units.
- The Air Surveillance, Air Threat Detection, Engagement of Air Defense Artillery and Tactical Army Aviation Subsystem (VIAER) which has the objective of gathering, evaluating and presenting information about enemy air activities, evaluating threats, and assigning targets to fire units.
- The Information Processing and Decision Making Support Subsystem (PROIN) which has the objective of gathering, evaluating and presenting information about the status of both own and enemy forces.

2. C^3 COMMAND CENTER STUDY

The C^3 Command Center Study was carried out by the C^3 Department to complement the C^3 System Study. This study established the following main capabilities to be performed by a C^3 command center: [Ref. 39: pp. 7-24]

1. Gathering, correlating and selecting data depending on its validation.
2. Processing the selected data.
3. Classifying, recording and storing data in the data bases.
4. Providing a wide or narrow selection of the interest zone of the battlefield.
5. Providing automatic and timely signaling when changes in the situation have occurred.
6. Providing a staff report selection to be presented to the commander.
7. Generating orders, information and intelligence to subordinate units.
8. Maintaining the alert state.

The capabilities that this C^3 command center would be able to supply to the different elements of the staff are listed in this study. Among the elements supported by the C^3 Center are as follows:

1. Commander or Chief of Staff
2. G1-Personnel
3. G2-Intelligence
4. G3-Operations
5. G4-Logistics
6. G5-Civilian Affairs
7. Fire Support Coordinator
8. Engineering Officer
9. Communication and Electronic Warfare Officer
10. Air Defense Element
11. Army Aviation Element

In conclusion, this study points out that the availability of all the above elements will optimize the performance of the land forces and thus increase their capabilities to achieve the objectives imposed by national authorities.The ultimate goal of the C^3 Commnad Center is to present a picture of the situation to the strategic or tactical commander, or to the national authorities when required. The C^3 Commad Center will be especially useful in crisis situations when a close monitoring of a particular situation is required.

C. THE MERGER OF TELECOMMUNICATIONS AND COMPUTERS

Another factor contributing to further development of C^3 systems concepts is the gradual automation of communications systems. The Argentine Army recognizes that the traditional separation of information processing and information transfer is becoming less distinct. These two different "worlds" which have been separated for years, now are coming together. The traditionally separated Directorate of the Automated Data Computation System (DISCAD) is now a part of the Directorate of Communication. It means to collocate the data processing function and the transmission function under a single command. Furthermore, the Department of C^3 has been put under the same Directorate of Communication.

D. THE TARGET INFORMATION SYSTEM

At the present, time the Argentine Army has a considerable investment in computer and communications equipment that has been procured and installed without regard to system integration or interoperability. The growth of these systems did not follow a centralized policy. Instead, they were installed to meet the inmediate needs of the users without regard to operational impact. The SIIFE Project (Sistema Informatico Integrado de la Fuerza Ejercio) was the first attempt to organize information processing in the A.A.. Because of changes in priorities with subsequent budget cuts, this project did not reach its original objectives, and the proposed integration stopped at the level of the Army Staff and its formations, thus omitting the corps, brigades and units.

In 1987, the DISCAD began another project (Project 10) in an attempt to continue the original SIIFE project. The target users in that case were one brigade and its subordinate units. The objective of that project was to implement systems to support logistical functions. Initially those systems were isolated. Later they were integrated into the SIIFE system. Besides these initiatives, many individual initiatives have surged recently, so the A.A. has actually hundreds of stand-alone systems in use in battalions, companies and squadrons.

The merging of communications and computers, the efforts made in integrating the Army Information System, and the studies performed by the C^3 Department of the Army Staff are good initial steps in the direction of effective C^3. To achieve good performance

in command and control activities. the Argentine Army has to integrate the concepts of C^2 into its current doctrine, and then start developing the C^3 architecture.

One parallel development is fundamental. The Argentine Army should establish an Army system architecture in order to establish a baseline for further developments. One practical approach to unify these efforts is for the Army to maximize the use of existing assets while it establishes an objective Master Information System Architecture. To do that, the Army information authority will have to carry out the following actions:

1. Develop an overview of current information system resources, and their structure and relationship to all external systems.
2. Analyze current capabilities of the available systems and determine inadequacies.
3. Make a listing of all requirements presented by the potential users.
4. Propose a recommended architecture, the alternatives and the preferred choice.
5. Establish a methodology for the integration of C^2 , telecommunications and MIS programs into a comprehensive architecture.
6. Develop a description of the present and future architecture in order to track the transition from the baseline to a fully integrated, operational architecture.
7. Define necessary program and projects within the architecture.
8. Fund requirements.

Once the architecture is defined and approved and the C^2 process is studied and adopted in the current doctrine, the C^3 authority should issue the guidance for the development of C^3 systems.The following considerations are necessary:

- Satisfaction of operational requirements
- Mobility of equipment
- Joint development efforts
- Intra/inter operability
- Standardization and commonality
- Simplicity of operation
- Integrated logistic support planning
- Transition to extensive, common user, secure, digital communications
- Effects of electronic warfare

E. SUMMARY

The first steps have been taken in the direction of designing the appropriate C^3 systems that fit the Argentine Army. The adoption of a C^2 process within army doctrine is still pending as is the development of an appropriated information architecture that is tailored to the Argentine Army's requirements. It has to be a coordinated effort between all branches within the army.

VII. CONCLUSION

The design of a C^3 architecture is an ambitious enterprise. This thesis only presented some ideas, processes, examples, models and suggestions for use in developing such a C^3 system, many of which are applicable for the Argentine Army C^3 project.

This thesis has been written with the objective of helping the Argentine Army in its efforts to design a C^3 system through the presentation of the basic concepts of C^2 process, C^3 system and C^3 architecture. This thesis has introduced the main ideas that the author, as an officer of the Argentine Army who is knowledgeable of the particular constraints and restrictions facing his army, has considered useful to investigate in this initial phase of development of C^3 concepts within the Argentine Army.

On occasion, and especially in times of changing technology and strategic problem situations, there are periods of considerable doctrinal ferment. Such a case is the Argentine Army doctrine, which is being revised and implemented. This thesis, through the inclusion of the C^2 process and C^3 system characteristics, adds more elements of interest to be taken into account in the doctrinal update of Argentine Army.

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